**CERTIFICATE OF ATTENDANCE**

I, the undersigned, Sébastien Lefèvre, General Chair of the AI4EO 2025 Symposium, hereby certify that,

**Angelica Maria MORENO ROJAS**

attended the AI4EO 2025 symposium held at IRISA in Rennes on 11 and 12 September 2025.

This certificate is issued for all legal purposes.

Done at Rennes on 12 September 2025.

Sébastien Lefèvre

AI4EO Symposium Chair

S. Lefèvre

IRISA

# AI4EO Symposium report


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# 1 Introduction

In mid-September, I had the privilege of serving as an assistant at the AI4EO 2025 Symposium in Rennes, France. Over two days, the program was packed with sessions that illuminated the state-of-the-art in Earth Observation  Artificial Intelligence : invited talks, contributed presentations, poster sessions, and panel discussions.I was able to explore advanced AI techniques being applied to remote sensing, engage with recent results in areas like environmental monitoring, land cover classification, change detection, and data fusion, and discuss challenges around scalability, model robustness, and data availability.

The symposium also offered excellent opportunities for networking — connecting with researchers, PhD students, and industry practitioners from across Europe. Being surrounded by people working at the cutting edge, exchanging ideas both in formal sessions and informal settings, left me inspired and better informed about where the field is headed.

As part of our assignment, we selected a poster and, after speaking with the presenter, received answers to several questions. The results of this exchange can be found on the following pages. In conclusion, the AI4EO Symposium was an excellent opportunity that greatly enriched our knowledge in the field, and I look forward to participating again next year.

**Title of the work :** Leveraging Deep Learning for Super-Resolution of GOME-2 Atmospheric Data Using TROPOMI Observations

**Presenter :** Aldo Cominetti, Università degli Studi di Ferrara (Meteorological and Environmental Earth Observation)

## 2 What is the problem ?

The work presented addresses the problem of limited spatial resolution in satellite-based atmospheric observations of nitrogen dioxide ($NO_2$). Specifically, the study focuses on the Global Ozone Monitoring Experiment-2 (GOME-2) instrument, which provides long-term $NO_2$ records but at a coarse spatial resolution. While GOME-2 is valuable for studying atmospheric chemistry and air pollution trends, its data does not resolve fine-scale spatial variations, especially over urban areas where $NO_2$ concentrations are most critical.

They use deep learning to apply super-resolution to GOME-2 data, with TROPOMI as reference, aiming to enhance GOME-2 spatial resolution to match finer-scale observations.

## 3 Why is it important ?

This problem is significant for several reasons :

— **Air Quality Monitoring :** $NO_2$ is a major pollutant emitted by traffic, power plants, and industrial activities. It directly impacts human health, contributing to respiratory diseases, and also plays a role in climate-relevant processes such as ozone formation. Accurate monitoring of $NO_2$ is crucial for environmental policy and public health.

— **Long-Term Climate Records :** GOME-2 provides a continuous record since 2006, whereas TROPOMI only started in 2018. By applying super-resolution methods, scientists can extend the high-resolution insights of TROPOMI back in time, creating a richer dataset spanning almost two decades.

— **Urban and Regional Studies :** Many policy-relevant applications require data at fine spatial resolution to capture hotspots, identify pollution sources, and evaluate mitigation measures. Raw GOME-2 data does not meet this need, so enhancing its resolution makes the dataset far more actionable.

In summary, this research addresses a critical gap between *long-term but coarse* datasets and *recent but fine-resolution* observations, enabling improved environmental monitoring and decision-making.

# 4 Strengths and Weaknesses

## Strengths

1. **Innovative Use of Deep Learning :** The application of residual dense networks to enhance satellite data resolution demonstrates a state-of-the-art approach that combines Earth observation with AI.
2. **Validation with Independent Ground Data :** The results are not only compared with TROPOMI but also validated against Pandora ground-based spectrometers and PGN (European ground-truth network), strengthening the scientific credibility.
3. **Pipeline Efficiency :** The code is integrated into a processing pipeline, allowing the method to run in just minutes and to be applied flexibly across different geographic areas.

## Weaknesses

1. **Temporal Mismatch :** The GOME-2 and TROPOMI data are not collected at the same time, with differences of up to 5 hours. This can introduce inconsistencies, especially in regions with rapidly changing $NO_2$ levels.
2. **Cloud Coverage Issues :** Pixels obscured by clouds or missing data are simply ignored in the analysis, which may bias results in cloudy regions.
3. **Restricted Access :** The results and code are not publicly released, since the work was primarily commissioned for the company owning GOME-2 data, limiting transparency and broader scientific reuse.
4. **Dependence on TROPOMI for Training :** The approach requires high-quality TROPOMI data as a reference. This limits transferability to regions or time periods where TROPOMI data may be missing or unavailable.

# 5 How to extend/reuse the work in a master thesis topic ?

Possible directions include :

- **Generalization to other pollutants and areas :** Applying similar methods to other atmospheric products (e.g., nitrogen dioxide, ozone, sulfur dioxide, carbon monoxide, methane, formaldehyde, and aerosols or particulate matter detected through the Aerosol Index) using datasets from different instruments and applying this to other areas for example, Latin America.
- **Handling cloudy pixels :** A particularly relevant thesis extension would be to address the cloud-coverage limitation. This could involve integrating

external datasets (e.g., meteorological reanalysis, MODIS cloud masks) or developing gap-filling approaches that intelligently reconstruct missing data rather than discarding it.

# 6 Explaining the research to a general audience

Imagine you are looking at the world from space through a blurry lens. Satellites like GOME-2 have been monitoring air pollution for many years, but the pictures they provide are fuzzy. They can tell us that pollution is present, but not precisely where it is strongest, especially in cities where traffic and industry are major sources.

In 2018, a new satellite instrument called TROPOMI started providing much sharper pictures of air pollution. The problem is that we only have these sharp images for a few years, while the blurrier ones go back almost 20 years.

The researchers found a clever way to fix this : they trained a computer to "sharpen" the old blurry images using the new sharp ones as examples. The computer learns patterns of how the blurry and sharp images relate, and then it can go back in time to sharpen the old data.

This means we can now look at pollution trends since 2006 in much greater detail. For example, we can see how air quality in big cities has changed over time, track the effect of policies, or understand how pollution responds to economic and environmental events. It's like upgrading your old photo albums with today's camera quality, giving us a much clearer picture of our atmosphere and its changes over time.